

PATENT SPECIFICATION

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(54) FOUNDRY CASTING FORMS

(71) We, THE WHITE SEA & BALTIC COMPANY LIMITED, a British Company, of Patman House, George Lane, South Woodford, London, E18 2SA, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 In making foundry moulds and cores the particles of the foundry sand used must be bound together. Both organic and inorganic binder compositions are known and compositions of both types are known which will cause setting at room temperature. If the binder composition used is such that the mixture of foundry sand and binder composition, before setting, behaves as a solid particulate mixture, the mixture has to be rammed or otherwise mechanically forced into the core or mould box used in order to make the mixture conform to the desired shape and in order to ensure uniformity of structure throughout the mould or core. Ramming or otherwise mechanically forcing the mixtures into core or mould boxes is a troublesome and time-consuming business, particularly if the desired mould or core is large and/or of an intricate shape. In an attempt to overcome this problem it has been proposed in British Patent Specification No. 1,085,651 to use a binder composition containing inorganic material which will set at room temperature in the presence of water, water and a foaming agent. The inorganic material may either comprise sodium or potassium silicate as binder and a distinct hardening agent e.g. bicalcium silicate or comprise a self hardening cement. A sufficient amount of the binder composition is mixed with the foundry sand so that the foamed aqueous phase renders the mixture fluid and thus easily pourable into mould or core boxes, any need for ramming or otherwise mechanically forcing the mixture into the boxes thereby being avoided.

The use of the binder compositions described above containing a foaming agent has

the serious disadvantage that an appreciable amount of water is needed to render the sand/binder composition mixture fluid and the presence of this water in the set mould or core renders it weak and in particular renders its surface friable. This disadvantage cannot be overcome simply by using conventional organic binder compositions e.g. aqueous solutions of, for example, urea/formaldehyde condensates, with the addition of a foaming agent since cores and moulds made in this way have poor strength if conventional amounts of the organic binder compositions are used. If larger amounts of the organic binder compositions are used the cores and moulds are unsatisfactory since, when they are used for casting, the high temperatures result in excessive amounts of gaseous products which tend to cause blow holes in the castings.

In an attempt to improve certain specific organic binder compositions not containing any foaming agent the addition of a silane has been proposed in British Patent Specification No. 1,143,351. Improvements have been obtained by use of such binder compositions but the problems associated with mechanically forcing sand/binder composition mixtures into core or mould boxes are not avoided by use of the binder compositions.

We have now found that surprisingly good foundry moulds or cores can be made very conveniently by use of a binder composition comprising a resin condensate, e.g. a condensate, in oligomeric form, of formaldehyde with one or more furfuryl alcohol, phenol and urea, a curing agent for the resin condensate, water, a foaming agent and a silane, preferably of general formula $R^1Si(OR)_3$ in which R^1 is a C_2-C_6 alkylene group bonded to an amino, epoxy, mercapto, hydroxy, hydroxy- C_1-C_6 alkylamino, amino- C_2-C_6 alkylamino, C_2-C_6 alkenyl or C_2-C_6 alkenyl-carboxy group and the groups R may be the same or different and are selected from C_1-C_6 alkyl and C_1-C_6 alkoxy-substituted- C_1-C_6 alkyl. Thus, in a method according to

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the invention for making foundry moulds or cores a fluid composition, comprising foundry sand and the components of the binder composition just described, in which the aqueous phase is foamed is poured into a core or mould box and allowed to set. By means of the method it is possible to make moulds or cores whose strength is surprisingly high even allowing for the presence of the silane. In the invention only rather small amounts of water are needed: normally less than 2.5% based on the weight of sand is used, preferably less than 2.0%. In Specification No. 1,085,651 appreciably larger amounts of water are used e.g. 5%. The use in the invention of the small amounts of water is an advantage compared with the use of larger amounts. Naturally in this invention the inorganic binders of Specification No. 1,085,651 are not used.

The resin condensates used are preferably furfuryl alcohol/formaldehyde, phenol/formaldehyde or urea/formaldehyde resin condensates but it can be advantageous for the binder composition also to contain free furfuryl alcohol. The resin condensates are usually water-soluble and are normally available and used in the form of aqueous compositions, e.g. solutions, containing from 1 to 30% by weight of water. The aqueous resin condensate composition is usually used in an amount of 1 to 5% based on the weight of the foundry sand e.g. 0.75 to 4.5% resin solids, preferably at least 1.75%, more preferably at least 2% resin solids. The amount of silane used need only be very small e.g. 0.05 to 0.5% by weight, preferably 0.1 to 0.2%, based on the total weight of aqueous resin condensate composition and silane.

Suitable curing agents for the resin condensates are well known, examples being 80 and 85% by weight phosphoric acid and 67% by weight *p*-toluene sulphonic acid. Also sulphuric acid in various concentrations can be used as can mixtures of two or all of the three named acids. We have found that aqueous solutions containing both *p*-toluene sulphonic acid and sulphuric acid are very satisfactory. Preferred solutions of this type contain from 50 to 70% by weight of water. The amount of curing agent used depends on the amount and nature of the resin condensate, on the desired setting time for the mixture of foundry sand and binder composition and on the nature of the curing agent itself. Usually the curing agent is used in an amount of 10% to 50% based on the weight of the aqueous resin condensate composition. In the case of curing agents containing relatively little water e.g. 80% by weight phosphoric acid suitable amounts are usually 10 to 100% by weight, preferably 50 to 75%, whereas curing agents of higher water content e.g. the solutions con-

taining both *p*-toluene sulphonic acid and sulphuric acid and having 50 to 70% by weight of water are normally used in amounts of 100 to 150% by weight. The curing agent will normally be used in an amount in the range of 0.5 to 2.5% based on the weight of the foundry sand.

The nature and amount of the curing agent used are particularly significant since they affect the rate of setting of the mould or core composition and the degree of fluidity of the composition at any particular time. Naturally these factors should be so chosen that, whilst the composition sets in a desirably short time, it does not set so rapidly that the degree of fluidity of the composition is reduced so quickly that its ability to fill the mould or core box properly, including the finer details of the cavity, is impaired. The nature and amount of the curing agent also influences the degree of porosity of the set moulds or cores. The fluid composition is non-porous as it behaves generally as a liquid but as the composition sets the foam bubbles break up so that after stripping the mould or core gradually develops permeability. If the nature and amount of the curing agent is such that the foam has collapsed to a considerable extent before the composition has set to any great extent the permeability will be higher than if the foam does not collapse so much during setting of the composition. The fact that moulds and cores having a considerable degree of permeability can be made by the process according to the invention is advantageous. Processes involving ramming or otherwise mechanically forcing the mould or core composition into the mould or core box give moulds or cores with lower permeability.

The mixture of foundry sand and binder composition must contain sufficient water in order for foaming of the aqueous phase to render the mixture fluid. Both the resin condensate and curing agent are normally used in the form of aqueous solutions but, if a curing agent containing relatively little water such as 80% by weight phosphoric acid is used, further water is generally required, usually in an amount of 0.5 to 2% based on the weight of foundry sand. If the curing agent contains a relatively large proportion of water addition of further water may be unnecessary.

The foaming agent used should be one which is effective in the presence of the other components of the binder composition, in particular in the presence of any acid used as curing agent for the resin condensate. A wide variety of materials are suitable as the foaming agent but alkali metal organic sulphates and sulphonates are preferred. Usually the foaming agent is used in an amount of 0.1 to 0.5% based on the weight of the foundry sand.

The mixture of foundry sand and binder composition can be made by adding and mixing the components in various orders but it is most convenient to add the water, curing agent and foaming agent to the foundry sand and to mix these components together so as to cause foaming and then to add, and mix in, the resin condensate composition and silane either together or separately.

- 10 It is convenient to use an aqueous composition containing both the curing agent and the foaming agent and this composition may contain all the water necessary in addition to that in the aqueous resin condensate composition. Preferred compositions of this type
15 contain 5 to 20% by weight of foaming agent e.g. Albright and Wilson's Empimin KSN 27, up to 50% by weight of *p*-toluene sulphonic acid (67% by weight aqueous solution), up to
20 50% by weight of phosphoric acid (80% by weight solution) and up to 85% of sulphuric acid (31.5% by weight aqueous solution). ("Empimin" is a Trade Mark.) A particularly preferred composition contains
25 9% by weight of Empimin KSN 27, 31% by weight of the *p*-toluene sulphonic acid and 60% by weight of the sulphuric acid.

The invention is illustrated by the following example.

- 30 *Example.*

(A) (Comparative).

- 1 Part by weight of water, 1.75 parts by weight of 80% by weight phosphoric acid
35 and 0.25 parts by weight of a foaming agent were mixed with 100 parts by weight of foundry sand, the mixing being such as to cause foaming of the aqueous phase. The foaming agent used was sodium lauryl ether
40 sulphate available from Albright and Wilson Limited, Marchon Division, under the name Empimin KSN 60. 3 Parts by weight of an aqueous resin condensate composition were then mixed into the mixture obtained above.
45 The aqueous resin condensate composition had a water content of 20% by weight and consisted of equal amounts of an aqueous urea/formaldehyde resin oligomer composition and furfuryl alcohol.

- 50 The mixture obtained as described above was poured into a mould and allowed to set. After 24 hours the compression strength of the sample was measured and found to be 110 kg/sq. in.

- 55 (B) The procedure of (A) above was repeated except that in the aqueous resin condensate composition 0.30% by weight of the furfuryl alcohol was replaced by γ -amino propyl triethoxy silane, a silane available
60 from Union Carbide under the designation A1100. After the final mixture had been in the mould for 24 hours the compression strength of the sample was measured and found to be 193 kg/sq.in., a 75% increase in
65 compression strength compared with that of

the sample obtained by procedure (A). The sample made by procedure (B) had a firm, non-friable surface.

Procedures (A) and (B) were repeated but in the absence of a foaming agent and added
70 water (and thus the initial mixture was not foamed) and using 2 parts by weight of aqueous resin condensate composition and 1 part by weight of 80% by weight phosphoric acid. It was found that, in this case,
75 the presence of silane caused a considerably smaller increase in compression strength of the sample i.e. only 43%.

The density of the samples made by procedures (A) and (B) was approximately 25%
80 lower than that of the samples made by the procedures where no foaming agent was used.

WHAT WE CLAIM IS:—

1. A method of making foundry moulds or cores comprising pouring into a mould or core box and allowing to set a fluid composition comprising foundry sand, a resin condensate, a curing agent for the condensate, water, a foaming agent and a silane, the aqueous phase of the composition poured into the box being in foamed form.

2. A method according to claim 1 in which the silane has the general formula $R^1Si(OR)_2$ in which R^1 is a C_2-C_6 alkylene group bonded to an amino, epoxy, mercapto, hydroxy, hydroxy- C_1-C_6 alkylamino, amino- C_2-C_6 alkylamino, C_2-C_6 alkenyl or C_2-C_6 alkenyl-carboxy group and the groups R may be the same or different and are selected from C_1-C_6 alkyl and C_1-C_6 alkoxy-substituted- C_1-C_6 alkyl.

3. A method according to either preceding claim in which the resin condensate is a condensate in oligomeric form of formaldehyde with one or more of furfuryl alcohol, phenol and urea.

4. A method according to any preceding claim in which the resin condensate is used in the form of an aqueous composition comprising 1 to 30% by weight of water.

5. A method according to claim 4 in which the silane is used in an amount of 0.05 to 0.5% by weight based on the total weight of the silane and aqueous resin condensate composition.

6. A method according to claim 4 or claim 5 in which the aqueous resin condensate composition is used in an amount of 1 to 5% based on the weight of the foundry sand.

7. A method according to any of claims 4 to 6 in which the curing agent is used in the form of an aqueous solution comprising one or more of phosphoric acid, *p*-toluene sulphonic acid and sulphuric acid.

8. A method according to claim 7 in which the curing agent is an aqueous solution comprising sulphuric acid and *p*-toluene sul- 130



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The mixture of foundry sand and binder composition can be made by adding and mixing the components in various orders but it is most convenient to add the water, curing agent and foaming agent to the foundry sand and to mix these components together so as to cause foaming and then to add, and mix in, the resin condensate composition and silane either together or separately.

- 10 It is convenient to use an aqueous composition containing both the curing agent and the foaming agent and this composition may contain all the water necessary in addition to that in the aqueous resin condensate composition. Preferred compositions of this type contain 5 to 20% by weight of foaming agent e.g. Albright and Wilson's Empimin KSN 27, up to 50% by weight of *p*-toluene sulphonic acid (67% by weight aqueous solution), up to 50% by weight of phosphoric acid (80% by weight solution) and up to 85% of sulphuric acid (31.5% by weight aqueous solution). ("Empimin" is a Trade Mark.) A particularly preferred composition contains 25 9% by weight of Empimin KSN 27, 31% by weight of the *p*-toluene sulphonic acid and 60% by weight of the sulphuric acid.

The invention is illustrated by the following example.

30 Example.

(A) (Comparative).

- 1 Part by weight of water, 1.75 parts by weight of 80% by weight phosphoric acid and 0.25 parts by weight of a foaming agent were mixed with 100 parts by weight of foundry sand, the mixing being such as to cause foaming of the aqueous phase. The foaming agent used was sodium lauryl ether sulphate available from Albright and Wilson Limited, Marchon Division, under the name Empimin KSN 60. 3 Parts by weight of an aqueous resin condensate composition were then mixed into the mixture obtained above. 45 The aqueous resin condensate composition had a water content of 20% by weight and consisted of equal amounts of an aqueous urea/formaldehyde resin oligomer composition and furfuryl alcohol.

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Procedures (A) and (B) were repeated but in the absence of a foaming agent and added 70 water (and thus the initial mixture was not foamed) and using 2 parts by weight of aqueous resin condensate composition and 1 part by weight of 80% by weight phosphoric acid. It was found that, in this case, the presence of silane caused a considerably smaller increase in compression strength of the sample i.e. only 43%.

The density of the samples made by procedures (A) and (B) was approximately 25% 80 lower than that of the samples made by the procedures where no foaming agent was used.

WHAT WE CLAIM IS:— 85

1. A method of making foundry moulds or cores comprising pouring into a mould or core box and allowing to set a fluid composition comprising foundry sand, a resin condensate, a curing agent for the condensate, water, a foaming agent and a silane, the aqueous phase of the composition poured into the box being in foamed form. 90

2. A method according to claim 1 in which the silane has the general formula $R^1Si(OR)_3$ in which R^1 is a C_2-C_6 alkylene group bonded to an amino, epoxy, mercapto, hydroxy, hydroxy- C_1-C_6 alkylamino, amino- C_2-C_6 alkylamino, C_2-C_6 alkenyl or C_2-C_6 alkenyl-carboxy group and the 100 groups R may be the same or different and are selected from C_1-C_6 alkyl and C_1-C_6 alkoxy-substituted- C_1-C_6 alkyl.

3. A method according to either preceding claim in which the resin condensate is a 105 condensate in oligomeric form of formaldehyde with one or more of furfuryl alcohol, phenol and urea.

4. A method according to any preceding claim in which the resin condensate is used 110 in the form of an aqueous composition comprising 1 to 30% by weight of water.

5. A method according to claim 4 in which the silane is used in an amount of 0.05 to 0.5% by weight based on the total weight 115 of the silane and aqueous resin condensate composition.

6. A method according to claim 4 or claim 5 in which the aqueous resin condensate composition is used in an amount of 1 120 to 5% based on the weight of the foundry sand.

7. A method according to any of claims 4 to 6 in which the curing agent is used in the form of an aqueous solution comprising 125 one or more of phosphoric acid, *p*-toluene sulphonic acid and sulphuric acid.

8. A method according to claim 7 in which the curing agent is an aqueous solution comprising sulphuric acid and *p*-toluene sul- 130

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- phonic acid having a water content in the range of 50 to 70% by weight and is used in an amount of 100 to 150% by weight based on the weight of the aqueous resin condensate composition.
9. A method according to claim 7 in which the curing agent is 80% by weight aqueous phosphoric acid and is used in an amount of 50 to 75% based on the weight of the aqueous resin condensate composition.
10. A method according to any preceding claim in which the foaming agent is used in an amount of 0.1 to 0.5% by weight based on the weight of the foundry sand.
11. A method according to any preceding claim in which the foaming agent is an alkali metal organic sulphate or sulphonate.
12. A method according to any preced-

ing claim in which the foamed composition is formed by adding water, curing agent and foaming agent to the foundry sand and then mixing these components so as to cause foaming of the aqueous phase and by then adding and mixing the resin condensate and silane either together or separately.

13. A method according to claim 1 substantially as hereinbefore described with reference to the Example.

14. A foundry mould or core made by a method according to any preceding claim.

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